

# The Renaissance, New Sciences, and Religious Wars in Europe

Part I

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# The Renaissance

- End of the 14<sup>th</sup> century
  - Decline of feudalism → new political, social entities
  - Achievements of Middle Ages pushed Western civilization in new direction
    - Creation of Western monarchies
    - Development of English law, Parliament
    - Foundation of universities
    - Vernacular works of literature
    - Revival of commerce
- Rise of the nation-states
- Universal access to commerce, capital

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# The Renaissance

- Change in intellectual pursuits
  - Education → more widely available
  - Movement away from Scholasticism to ancient Latin, Greek classics
- Familiarity with texts = desire to return to Greco-Roman civilization
  - Re-awaken sense of human beauty, appreciate man's achievements
- Period given the name “Renaissance” by 19<sup>th</sup> century French historian
  - “Rebirth”
  - Misnomer
  - Preceded by proto-Renaissance (app. 1300-1400)
  - Renaissance itself only lasted a little over 100 years (1400-1517/1527/1564)

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# The Renaissance

- Postclassical period → 500 AD – 1500 AD
- Modern Period → 1500 - Present
  - Early Modern Period → 1500-1789
  - Mid-modern Period → 1789-1914
  - Contemporary Period → 1914-Present
- Early Modern Period encompasses:
  - Renaissance, Age of Exploration, Baroque, Age of Reason, Enlightenment, beginning of French Revolution
  - Renaissance and Baroque ages are characterized largely by art





# The Fall of Constantinople and the Rise of the Italian Free Cities

- Economic growth of Italian cities → key contribution to Renaissance
  - Italian cities → centers of commerce
  - Formed society based on merchants and commerce → buy and sell freely
  - Growth aided by 70-year papal absence from Rome (Avignon papacy)
- Decentralization in Italy → noble families set up own governments
  - Rise of independence among nobility → petty wars



# The Fall of Constantinople and the Rise of the Italian Free States

- As Byzantine Empire declined in the East, center of trade shifted to Italian cities
  - Dramatic increase of goods, merchants → strong business economy
- Growth of free trade, significant increase of scholarship
  - Influx of Greek intellectuals → fleeing instability of Constantinople
- May 29, 1453 → Constantinople falls to the Ottoman Turks



# The Fall of Constantinople and the Rise of the Italian Free States

- Italian city-states greatly benefited from decline and fall of Constantinople
  - Shifted trade to Venice, Genoa, Florence
  - Italian ports → greater center of ideas from areas outside of Christendom
  - Unprecedented levels of toleration

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# The Italian World of the 15<sup>th</sup> Century

- Increased urbanization
  - Peasants moving to the cities → trade, sell goods
  - Feudalism had never been as strong in Italy as elsewhere
  - Urbanized populations → relatively independent
  - Independence → acquisition of great wealth among business class



# The Italian World of the 15<sup>th</sup> Century

- Prosperous city-state → rise of the middle class
  - Involvement of ordinary people in political life
- Education became more vital
  - Demand for less theological, more humanistic curriculum
    - *Studia humanitatis*
  - Emphasis on Classical texts, literature
- Not free, democratic in modern sense but each citizen had great control over his own life
  - Greater independence, individuality led to wider demand for, possibility of education

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# The Italian World of the 15<sup>th</sup> Century

- Italian city-states not nationalistic
  - No strong sense of national identity/unity
  - Local dialects, customs, cuisine, family ties
  - Smaller, independent regions – little in common with each other

# The Birth of Humanism and the Flourishing of Arts and Letters



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# Academia

- Academic emphasis changed in the new schools of the 15<sup>th</sup> century
  - Rhetoric
  - Grammar
  - History
  - Less emphasis on theological studies
- Curriculum
  - Studied classical works of Greco-Roman civilization
  - A more secular education than found with Scholasticism





# Academia

- Increased focus on ancient world → rising enthusiasm for ancient literature, art, architecture
  - Revive Rome's culture, civilization
  - Look to antiquity for lessons for contemporary Europe

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# Man and God

- Increased emphasis on the individual
  - Man's form, beauty, usefulness in society
- Ancient world → certain fascination with human achievement, individual's ability to shape own destiny
  - Focus on the wonders of man's abilities
  - No longer at the mercy of chance
- Medieval man sought his fortune in the next world while Renaissance man focused more on the here and now

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# Decline of Scholasticism

- Underwent steady decline in 14<sup>th</sup>, 15<sup>th</sup> centuries
  - Had become extremely formulaic
- Medieval philosophy seen as old, monkish, stagnant
  - Overly intricate subtleties, distinctions, technicalities
- Accused Scholasticism of ignoring most important questions concerning human subject:
  - What am I?
  - What is my final purpose?
  - What ought I do?
  - What should I love?
  - What follows death?

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# Decline of Scholasticism

- Attacked and questioned by nominalism
  - Associated with William of Ockham (14<sup>th</sup> century English theologian, philosopher)
  - Argues that true knowledge pertains to empirical knowledge only, not to metaphysical concepts



# Humanism

- What is humanism?
  - Certain ambiguity in meaning
  - General mood, intellectual climate which focuses on the richness of the human spirit over the almost exclusive theological focus of the Medieval era
- Writers, thinkers labeled “humanists” very diverse in aims, beliefs
  - Term “humanism” loses precision without clarifying term
- Literary genre → elaborate on different facets of human life
  - Spilled over into fine arts

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# Humanism

- Rebelled at specialized education
  - Did not include the exciting matter of human condition
  - Education should not only offer training, but also the moral purpose of making the individual wiser, more virtuous



# Humanism and Learning

- Revived study of great ancient Roman authors
  - Virgil
  - Cicero
  - Ovid
  - Seneca
  - Tacitus
  - Catullus
- Increased knowledge of Greek culture → Byzantine refugees
  - Homer
  - Aristotle
  - Plato
  - Thucydides

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# Humanism and Learning

- Called the Greco-Roman works “Bonae litterae (good letters) or *litterae humaniores* (more humane letters)”
  - Texts focus on man’s relation to the world rather than to God, eternal salvation
- Roots of Humanism in the Middle Ages
  - Dante Alighieri (1265-1321) → *The Divine Comedy*
    - *Struck a balance between person’s earthly condition and life after death*
  - Petrarch (1304-1374) → Father of Humanism
    - Much of his fame comes from his poetry (Laura)
  - Boccaccio (1313-1375) → *Decameron*
    - *Collection of one hundred stories told by ten travelers*
    - *Resource for understanding life in the Italian city-states*
    - *Opened the door to a new, secular era of literature, culture*



# Cultural Transformations:

Renaissance, Baroque, and New Sciences



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# The Renaissance and Baroque Arts

- Period of cultural transformation
- Renaissance was an outgrowth of scholasticism
  - Broken away from scholastic precepts
- Powerfully influenced by writings of Greco-Roman authors not widely known during previous age

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# The Renaissance

- Not a sudden break from the past
  - Gradual
  - Natural progression of thought
- Largely an artistic renaissance, rather than scientific
  - Rising middle class
  - Wealthy merchant and aristocratic classes
  - Increase in leisure time
  - Translated Ancients
- Late 15<sup>th</sup> century Renaissance → first in a sequence of cultural transformations
  - Rapid succession

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# The Renaissance and Baroque Art

- Texts of all the ancients, except Thucydides, were known and read in Western Europe
  - Fallacy that they were “rediscovered” in 15<sup>th</sup> century
- Term itself – “The Renaissance” is misleading (19<sup>th</sup> century)
  - Carolingian renaissance (9<sup>th</sup> century)
  - 12<sup>th</sup> century renaissance
- Influx of Byzantine scholars from Constantinople in Italy
  - Fleeing instability, collapse of the city
- Humanism was not a unique philosophical development of the Renaissance
  - 12<sup>th</sup> century renaissance

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# New Manuscripts and Printing

- Byzantine revival (1261-1453)
  - Vigorous debate – Plato vs. Aristotle
- Complete corpus of Plato's work to Western Europe
  - Eastern Christian scholars → Florence, Rome, Venice
- Translations
  - Hesiod, Homer
  - Greek tragedies, comedies
- Development of new script
- Vellum replaced by paper
  - Less expensive



# Philology and Political Theory

- Increase in study of Greek, Latin, and Hebrew philology
  - the branch of knowledge that deals with the structure, historical development, and relationships of a language or languages
- Desiderius Erasmus
  - Greek and Latin New Testaments
- Critical textual research → foundations in Renaissance

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# Philology and Political Theory

- Nicolo Machiavelli (1469-1527)
  - One of the founders of modern political thought
  - Spent many years in political arena of warring Italian city-states
  - Bitter experience of exile, betrayal
- *The Prince*
  - Written in reaction to precarious political situation
  - Radical development of classical political ideals of justice, clemency, and magnanimity



# Philology and Political Theory

- Political thought
  - Not achievable through classical, Christian methods
  - Saw papacy as an obstacle to Italian unity
  - Viewed virtues of mercy, humility, pity as obstacles to political effectiveness
  - “Unifier” needed intuitive strength, valor, indomitable spirit
  - Inspired by Aristotle → political realist
- Political theories do not completely reject classical, Christian virtues
  - Cast them down from preeminent positions
  - “The ends justify the means” as an absolute finds its origins somewhat in Machiavelli’s thought





# Philology and Political Theory

- Machiavelli represented major element of humanist Renaissance writers
  - Focused on secular world
- Growing split between religious and secular life → significant historical development
  - Pagan cultures → gods and spirits everywhere, plan integral part in human existence
  - Ancient Greece and Rome → political, social, economic life was in part dictated by an objective moral law
  - Early Christians → religion dominated everyday life
  - Middle Ages → rise of monasticism, integral to structure of Western civilization

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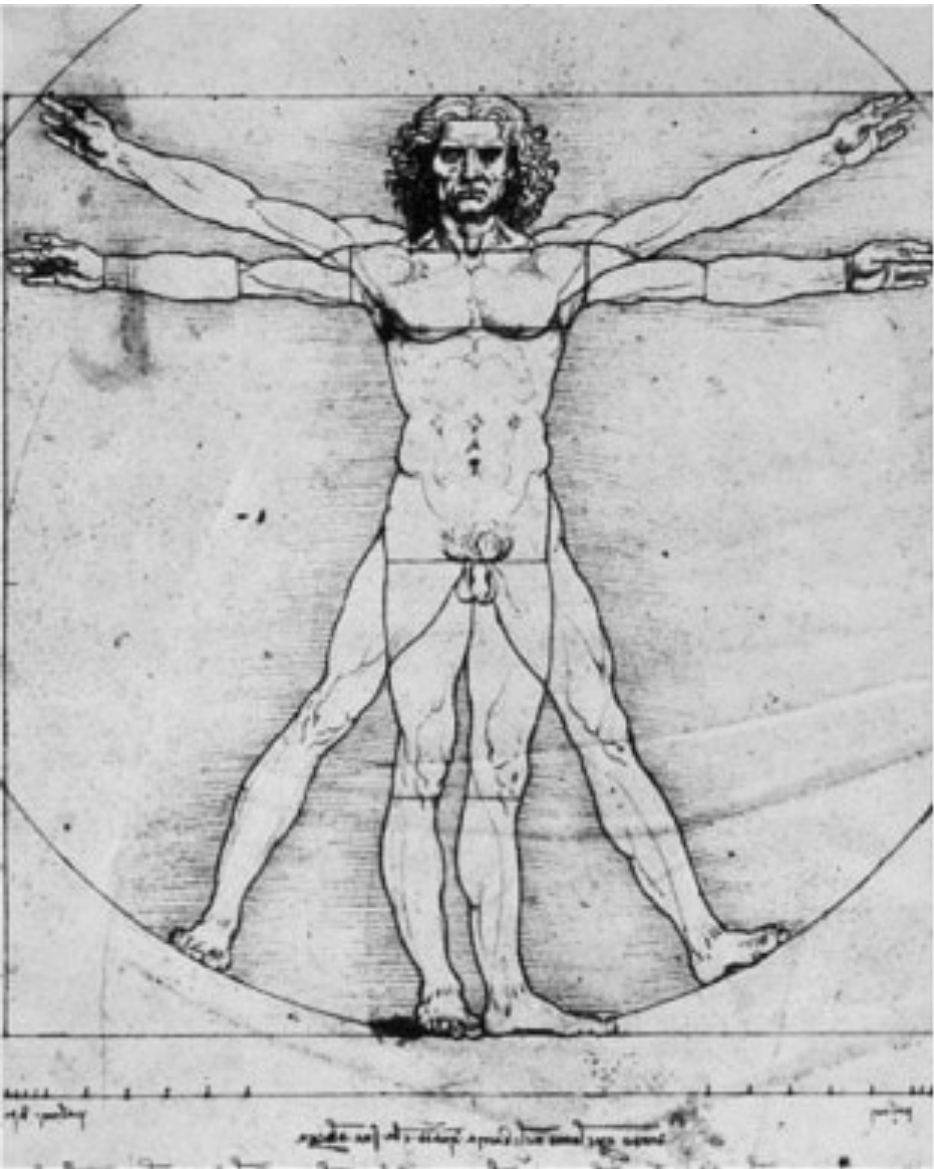
# The Renaissance Arts

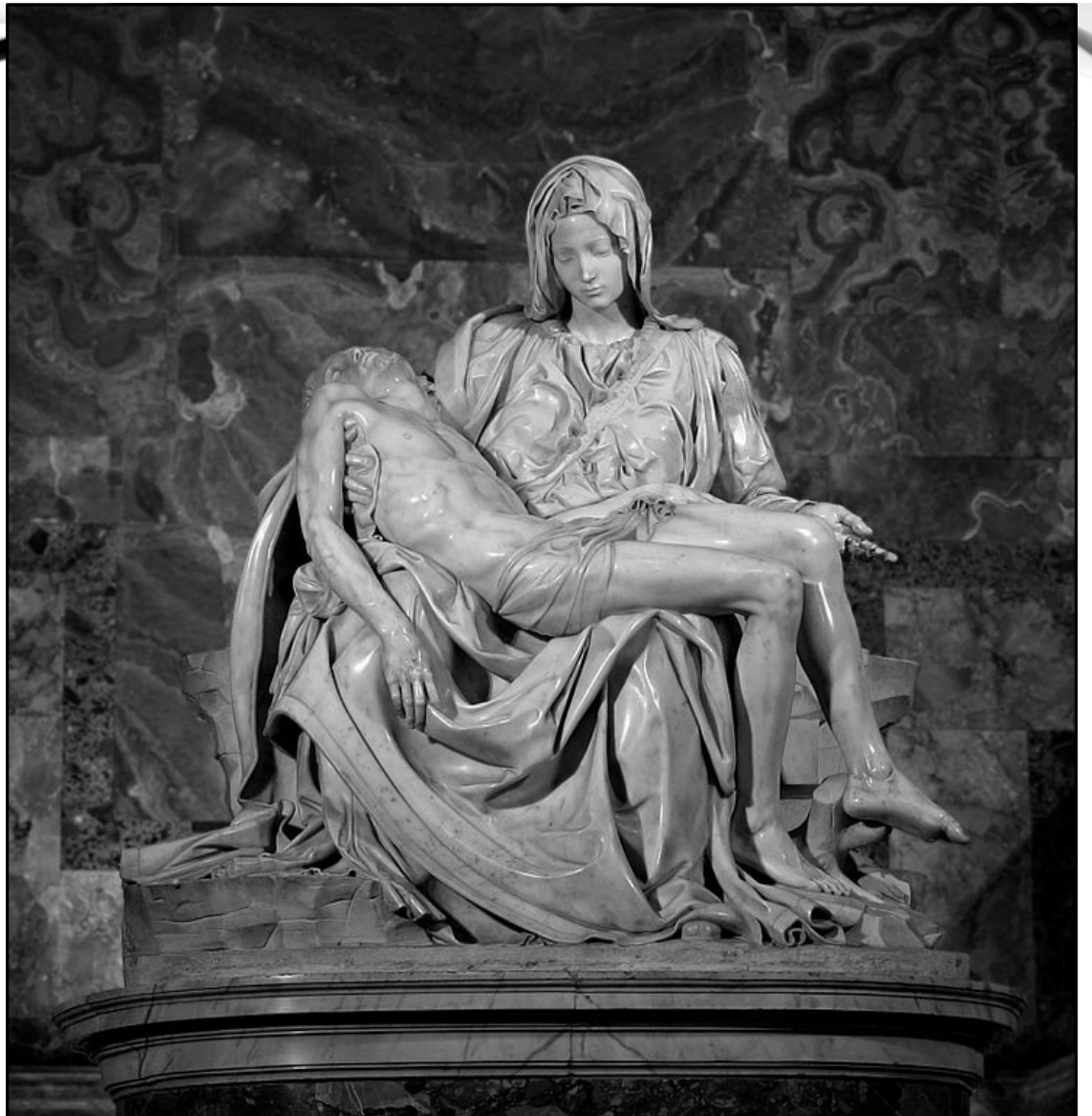
- Especially reflects the new mindset of the 15<sup>th</sup> and 16<sup>th</sup> centuries
- Art → considered to be pinnacle of human achievement
  - Human person could display skill, ability in crafting beautiful work exhibited in perfect form, balance, composition
  - Aristocracy → responsible in great part in promoting the arts
- Distinguished Renaissance world from the religiously-centered Medieval period

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# The Renaissance Arts

- New artistic perspective
  - Donatello (1386-1466)
  - Filippo Brunelleschi (1377-1446)
- Inspiration from Roman imperial statues and ruins
- Artistic triumvirate
  - Leonardo da Vinci (1452-1519)
  - Michelangelo Buonarroti (1475-1564) – (Source 17.4)
  - Raphael (1483-1520)









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# The Renaissance Arts

- Musical composers
  - 1<sup>st</sup> half of the 15<sup>th</sup> century – Platonists
- Problem – music of Greeks, Romans completely unknown
  - Partial solution – emphasizing relationship between the word (rhetoric) and music
- 16<sup>th</sup> century
  - Liturgical needs of Catholic, Protestant churches
  - Hymns, Masses, madrigals
  - Giovanni Pierluigi de Palestrina (1525-1594)

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# The Renaissance Arts

- Theater
  - Rooted in Medieval mystery, passion, and morality plays
- Italy (15<sup>th</sup> century) - *commedia dell'arte*
  - Forbidden love, jealousy, adultery
- England (16<sup>th</sup> century)
  - Traveling theater troupes became stationary and professional
  - Playwrights sponsored by aristocracy, Elizabethan court – hundreds of scripts
  - William Shakespeare



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# The Baroque Arts

- 1600 → Final transition from Renaissance to Baroque
  - Dominated until approximately 1750
- Two factors
  - Protestant Reformation, Catholic Reformation (Council of Trent), religious wars
  - Greater spontaneity and dramatic effect



## Renaissance

- ✓ serenity
- ✓ eternal
- ✓ stability
- ✓ horizontals / verticals
- ✓ calm nobility
- ✓ more reserved / distant
- ✓ idealized

Michelangelo, *David*, 1501-4

## Baroque

- ✓ emotional intensity
- ✓ a moment in time
- ✓ dynamism
- ✓ diagonals
- ✓ energy / movement
- ✓ involving / close
- ✓ real / not idealized



Bernini *David*, 1623-24

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# The Baroque Arts

- Shift in church and palace architecture to baroque voluptuousness
  - Bavarian, Austrian Catholic churches
  - Versailles Palace
  - St. Paul's Cathedral
- Baroque music
  - Church, palace patronage
  - Antonio Vivaldi, Johann Sebastian Bach







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# The New Sciences

- Renaissance was not a period of immense scientific discovery
  - Many historians consider the initial period of the Renaissance to be one of scientific regression
  - Not until late 16<sup>th</sup> century that significant scientific figures appeared
- The Renaissance was a period of artistic growth rather than scientific advancement
- Rise of superstition during the Renaissance
  - Alchemy
  - Witchcraft
  - Astrology
  - Necromancy





# Copernicus's Incipient New Science

- Aristotle – four elements
  - Earth
  - Water
  - Air
  - Fire
- In astronomical terms, our elements formed distinct layers → shaped the world
  - Did not apply in geographical terms
  - “Floating apple”





# Copernicus's Incipient New Science

- Ptolemy was well-known by Medieval scholars
  - Discussed by St. Thomas Aquinas
  - Mathematics of Ptolemy supported Aristotelian (geocentric) concept of the universe
- *Geography* by Ptolemy
  - Concept of a globe composed of a single sphere of intermingled earth and water



# Copernicus's Incipient New Science

- Geocentric theory
  - Endorsed by Aristotle, given mathematical probability by Ptolemy
  - Prevailing model for 1500 years → made sense according to what was known prior to the invention of the telescope
- Heliocentric theory
  - Aristarchus vs. Aristotle
  - Nicole d'Oresme
  - Bishop Nicholas of Cusa
  - Nicolaus Copernicus

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# Aristotleian-Ptolemaic Synthesis

- Geocentric model of the universe
  - Based on what could be observed → empiricism
  - Complex system
  - Numerous epicycles (paths of heavenly bodies)
  - Mathematical model → did not correspond to physical reality of the universe
- Heliocentric model rejected by ancients – why?
  - No Coriolis effects (force that acts on a rotating object)
  - No stellar parallax (shift of any nearby star against background of distant objects)
  - Argument from the winds
  - Argument from the arrow
- All empirical evidence indicated that the earth was at the center of the universe

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# Copernicus

- Nicolaus Copernicus (1473-1543)
  - University of Kraków
  - Graduated with a degree in canon (Catholic Church) law
  - Canon and Secular Dominican
- *Commentariolus* (1514)
  - Brief theoretical description of world's heliocentric mechanism
  - 1533, 1536
  - Strongly opposed by Martin Luther, Philip Melanchthon

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# Copernicus

- *On the Revolution of the Celestial Orbs* (1543)
  - Bishop Giese of Culm
  - Major work on heliocentric theory
  - Listed seven assumptions that supported the theory
  - Dedicated to Pope Paul III
  - Published near the end of his life
- Argued that universe was made of eight spheres
  - Outermost → motionless, fixed stars, sun
  - Planets revolved around sun, each with own sphere
  - Daily revolutions of sun, stars → Earth's rotation on its axis
- Believed that motions of celestial bodies were uniform circular motions
  - Ellipses

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# Copernicus

- Theories seen as a hypothesis for charting movements of the planets
  - Copernicus could offer no concrete proof of his theories
  - Alphonsine Tables → recalculated
  - Based almost entirely on mathematical calculations
- Solved several problems with Ptolemaic model
  - Contained even more epicycles
- Criticisms from ancient Greeks could still not be answered
  - Constant wind?
  - “Arrow” question



# Copernicus, Galileo, and the 16<sup>th</sup> Century

- Heliocentrism
  - Copernicus's work was generally rejected by most scientists
  - Relatively uncontroversial
  - Used by Pope Gregory XIII to reform the calendar in 1582
- Seven competing models
  - Heraclidean – Geo-heliocentric, mercury and Venus circle Sun; everything else circles Earth
  - Ptolemaic – Geocentric, stationary Earth
  - Copernican – Heliocentric, pure circles with lots of epicycles
  - Gilbertian – Geocentric, rotating Earth
  - Tychonic – Geo-heliocentric, Sun and Moon circle the Earth; everything else circles the Sun
  - Ursine – Tychonic, with rotating earth
  - Keplerian – Heliocentric, elliptical orbits

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# Running Afoul of the Church

- Galileo Galilei
  - Talented mathematician
  - Taught geometry, mechanics, astronomy
- Telescope
  - Hans Lippershey (1608)
  - Galileo increased magnification 30x (1609)
- Discoveries in astronomy
  - Moon is not a perfect sphere
  - Observation of sunspots → rotation of the sun
  - Discovered that Jupiter had at least four satellites (Galilean moons)\*
  - Observed phases of Venus → moves around the sun, not the earth\*



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# Running Afoul of the Church

- Galileo discovered Jovian moons on January 7, 1610
- March 26, 1611 → arrived in Rome to publish a book on his discoveries
  - Hosted and entertained by various churchmen, Jesuits
- April 19, 1611 → Cardinal Bellarmine requested confirmation of Galileo's discoveries from Jesuit scientists at the Collegio Romano
  - Jovian moons were confirmed
- April 22, 1611 → Galileo is received by the Pope and is honored for his discoveries
- May 13, 1611 → honored at a banquet by the Jesuits
  - Given an honorary doctorate

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# Politics and Science

- 16<sup>th</sup> century Europe
  - Reformation
  - Thirty Year' War
  - Catholic Counter-Reformation
- Limits of acceptable theology → narrowed
  - Pope Urban VIII, other officials proposed ways to avoid conflicts between science, theology
  - Friar Marin Mersenne → “defend [your] studies on grounds that God is free to place the earth anywhere He likes, and it is the duty of scientists to find out where He had put it”.

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# Running Afoul of the Church

- Still could not *prove* heliocentrism
  - Could not answer questions that had plagued Ancient Greeks, Copernicus → stellar paralaxes, Coriolis effect, etc.
- Lack of evidence → primary reason majority of astronomers did not accept Copernicus, Galileo
- Tycho Brahe
  - Measurements of star diameters
- Movement into the arena of theology
  - Compatibility with Scripture
  - Independent interpretation of Scripture



# Running Afoul of the Church

- 1615 → Galileo's writings on heliocentrism submitted to Roman Inquisition
  - Claimed that Galileo was attempting to reinterpret the Bible (Source 17.5)
  - Debate with Monsignor Francesco Ignoli
  - Focused on physical, mathematical arguments
- 1616 → Commission declared heliocentrism is "foolish and absurd in philosophy"
  - Cardinal Robert Bellarmine
- Galileo is ordered to stop presenting heliocentrism as provable fact
  - "Not to hold, teach, or defend it in any way whatever, either orally or in writing".
  - Could discuss it as a mathematical and philosophic idea → could not advocate its physical truth

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# Running Afoul of the Church

- Galileo promised not to hold or publish Copernican theory as scientific fact, but only as an unproven theory or hypothesis

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# Conflict Over Comets

- Father Orazio Grassi
  - Professor of mathematics at the Collegio Romano
- 1619 → Father Grassi published a pamphlet which discussed the nature of a comet
  - Concluded that the comet was “fiery body which had moved along a segment of a great circle at a constant distance from the earth”
- Galileo disagreed → said they were optical illusions
- War of words between Grassi, Galileo
  - Uncomplimentary remarks/insults re: Jesuits, Collegio Romano alienated the Jesuits, who had been some of his strongest defenders

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# Running Afoul of the Church

- Pope Urban VIII (reigned 1623-1644)
  - Friend and admirer of Galileo
  - Opposed condemnation of Galileo in 1616
- Asked Galileo to write a book giving pro and con arguments for both Ptolemaic and heliocentric theories
  - Careful not to advocate heliocentrism
  - Pope asked that his (the Pope's) own views on the matter be included

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# Running Afoul of the Church

- 1632 – *Dialogue Concerning the Two Chief World Systems*
  - Three speakers – two philosophers, one layman
  - Layman – Simplicio (“Simpleton”/“Idiot”)
- Simplicio → presents traditional Aristotelian-Ptolemaic views
  - Put the words of the Pope in this character’s mouth
- Simplicio’s arguments systematically refuted with “unassailable proof” for Copernican theory
  - Made Galileo’s position very clear
- Further alienated Jesuits by attacking one of their astronomers in the book



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# Running Afoul of the Church

- Seen as a violation of 1616 agreement
  - Taken as an open public challenge
  - Pope infuriated
- 1633 → trial in Rome
  - Focused on whether he had violated the decree issued in 1616
- Found suspect of heresy → continued promotion of unproven heliocentrism, personal interpretation of Scripture
- Galileo retracted his statements
  - Placed under house arrest at his villa in Tuscany
  - Ordered to keep silent on the issue for the rest of his life
  - *Two New Sciences*
- Died nine years later

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# Running Afoul of the Church

- Why did the Church require a retraction from Galileo?
  - Possibility of alternative theories
  - Upsetting the beliefs of simple people
  - Harm done to attempts at reconciliation with Protestant churches
  - Blanket discrediting of scientific, philosophical authorities

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# Johannes Kepler

- Johannes Kepler (1571-1630)
  - German mathematician, astronomer
  - Copernican → improved Copernican theory
  - Lutheran scientist; imperial scientist to Holy Roman Emperor Rudolph II
- *The Cosmographic Mystery* (1596)
  - First published defense of the Copernican system
  - Believed that he had revealed God's geometrical plan for the universe → the universe itself was an image of God
- *A New Astronomy* (1609)
  - Calculated entire orbit of Mars → hit upon the idea of ellipse
  - All planets move in ellipses with the sun at one focus
- Laws of Planetary motion (1609, 1619)
- Father of modern refracting telescopes

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# Running Afoul of the Church

- A shifting center?
  - 17<sup>th</sup> century → interest in the New Sciences shifted
  - Lack of powerful church authority, either Catholic or Protestant
- New Scientists in northern Europe → certain liberty
  - Relative intellectual freedom rather than sympathy from religious authorities
- Flourished, especially in England and the Netherlands

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# Spanish Natural Sciences

- Southern European countries → well situated to make substantial scientific contributions
  - Spain
- New colonies
  - Botanists, geographers, ethnographers, physicians, metallurgists
  - Researched new plants, diseases, peoples, mineral resources of the new world
- Accumulated voluminous amount of knowledge
  - Jealously guarded by Habsburgs

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# Isaac Newton's Mechanics

- Isaac Newton (1643-1727)
  - English physicist
  - Brought New Sciences of Copernicus, Galileo, and Kepler to culmination
- Professor at the University of Cambridge
  - Mathematics, optics, astronomy, physics, alchemy, theology
- 1665 – 1667 → developed theories of calculus
  - Gottfried Wilhelm Leibniz (1646-1716)
- *Mathematical Principles of Natural Philosophy* (1687)
  - Updated Galileo's experimental method
  - Proved Kepler's laws of planetary motion mathematically
  - Stated his belief in and rationale for heliocentrism



# The New Sciences and Their Social Impact

- 17<sup>th</sup> century scientists → close communication with each other
  - Scientific societies
  - Salons
- Improvements in scientific instruments
  - Telescopes
  - Microscopes
  - Thermometers
  - Barometers
- Experiments
  - Vacuum chambers
  - Cylinders operating with condensing steam

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# New Science Societies

- Chartered scientific societies
  - Royal Society of London (1660)
  - Paris Academy of Sciences (1666)
  - Prussia, Russia, Sweden
- Academies
  - Staff of administrators
  - Scientists as fellows
  - Regular discussion meetings
  - Challenged fellows to answer scientific questions
  - Awarded prizes
  - Organized expeditions
  - Published transactions, correspondences, monographs



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# New Science Societies

- Amateur scientists
  - Textbook authors, itinerant lecturers
  - Middle-class amateurs
  - Instrument makers
  - Specialized craftspeople
- Meeting places
  - Coffeehouses
  - Urban homes
  - Country estates
  - Provincial schools

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# New Science Societies

- Coffeehouses
  - Allowed literate urban public to meet, exchange ideas
  - Coffee preferred non-alcoholic drink before tea was popularized among the upper classes by Queen Catherine of Braganza, wife of King Charles II, after their marriage in 1662
- Lecturers
  - “Newtonianism lite”
  - Subscriptions
  - Public lectures
- Important role of large, scientifically and technically interested public



# Women, Social Salons, and the New Science

- Women → significant part of public interested in science
  - Sophie Brahe (1556-1643)
  - Marie Cunitz (1607-1664)
- Estimates
  - Second half of 17<sup>th</sup> century → 14% of German astronomers were women
- Practiced science privately
  - Germany, Poland, the Netherlands, France, England

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# Women, Social Salons, and the New Science

- Salon
  - Well-furnished, elegant living room of an urban residence
  - Domestic chamber and semipublic meeting space
  - Made female participation possible
- Culture emerged first in Paris after 1580s
  - Places of new information
- Gabrielle-Emilie du Châtelet (1706-1749)
  - Marquise du Châtelet
  - Mother of three
  - Turned to science after raising her children
  - François-Marie Arouet (Voltaire)
  - Translation of *Mathematical Principles* (1759)

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# Discovery of the Vacuum

- Important scientific instruments
  - Telescopes
  - Microscopes
  - Thermometers
- Barometer → crucial instrument
  - Exploration of the properties of the vacuum, condensing steam



# Discovery of the Vacuum

- Evangelista Torricelli (1608-1647)
  - Laid the groundwork
  - Experimented with mercury-filled glass tubes
- Blaise Pascal (1623-1662)
  - Invented hydraulic press, syringe
  - Mercury barometer experiment → atmospheric pressure
- Vacuum → important step towards mechanical engineering

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# The Steam Engine

- Denis Papin (1647-1712)
  - French Huguenot
  - First step from vacuum chamber to steam engine
  - 1690 → constructed a cylinder with a piston
- 1712 → Thomas Newcomen built the first steam engine



# Descartes' New Philosophy

- René Descartes (1596-1650)
  - French lawyer
  - Served in Dutch and Bavarian courts
  - Shocked by Galileo's conviction, delayed publication of a book on heliocentrism
  - Considered himself a devout Catholic, strong belief in God
  - Father of modern philosophy
- *Meditations on First Philosophy* (1641)
  - Addresses basic foundation of human knowledge
  - Attempt to show compatibility of religion and science





# Descartes' New Philosophy

- Argument
  - Cannot trust senses to be the foundation of all knowledge
  - Cannot trust mathematics as the foundation of all knowledge
  - *Cognito ergo sum*
- Senses
  - Illusions
  - Dreams
  - “Wax argument”
- Mathematics
  - “Evil demon”
- *Cognito ergo sum*
  - “I think, therefore I am”



# Descartes' New Philosophy

- From the very fact that one can be deceived, one knows that one exists
  - Can examine thoughts to see if any prove themselves to be undoubtable
- Finds one such thought in his head → a perfect being
  - Says he could not have gotten the idea of a perfect being unless it had been put in his head by a perfect being
- All-loving, all-powerful God would never allow senses to systematically deceive → can generally trust senses because material objects exist
  - Can trust what is seen in a telescope

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# Descartes' New Philosophy

- Man is composed of two radically different substances
  - Material substance → body/senses
  - Immaterial substance → thinking mind
- Mind and body → two profoundly different realms of reality



# Variations on Descartes' New Philosophy

- Radical distinction between body and mind → lively debate
  - Dualism → which was real? Conceptual? More fundamental?
  - Baruch Spinoza, Thomas Hobbes, John Locke
- Baruch Spinoza (1632-1677)
  - Dutch Jewish philosopher of Sephardic Portuguese extraction
  - Worked as a lens grinder
  - Descartes' distinction → understood only in conceptual sense
  - Developed complicated system → integrate Galilean nature with ideas of God, Good, Just
  - Excommunicated by his Jewish community for heresy

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# Variations on Descartes' New Philosophy

- Thomas Hobbes (1588-1679)
  - English philosopher
  - Accepted Descartes' distinction → took it farther
  - Body = fundamental reality; mind = dependent function
  - Focused on bodily passions as principal human character trait
- *Leviathan* (1651)
  - Grim picture of mankind
  - "Solitary, poor, nasty, brutish, and short".
  - Believed without the imposition of a strong political structure, people would destroy each other, society would collapse
  - State = unity = absolute authority
  - Social contract

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# Variations on Descartes' New Philosophy

- John Locke (1632-1704)
  - English philosopher
  - Held same position on Descartes as Hobbes
  - Same opinion on body, mind
- Social contract
  - Differed from Hobbes
  - Individuals engaged as equals in social contract
  - Human nature governed by reason, tolerance
  - Government → protected their property, established civil society
  - Governed by law
  - Huge influence on the Founding Fathers of the United States

# Centralizing States and Religious Upheaval



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# The Rise of Centralized Kingdoms

- Emergence of states
  - Transition from manorial knights to professional armies
  - Rulers → strengthen power of administrations
- Centralization of power
  - Collect higher taxes → subsidize infantries
  - Curb power of nobility, cities, local institutions





# The Demographic Curve

- European population expanded after 1470
  - Reached pre-Black Death levels (1348) around 1550
  - 85 million inhabitants → excluding Ottoman Empire, Habsburg Empire
- Continued to grow until about 1660 (90 million)
  - Entered period of stagnation → little ice age (1550-1750)
- 1650-1750 → period of moderate population growth
  - From 105 million to 140 million
- In 1750, France (28 million) and Russia (21 million) were the most populous
  - Germany, Italy, Poland, England, the Netherlands, Sweden

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# The Demographic Curve

- Population figures did not reflect countries' political importance
- Overall figures for Europe → Western Christianity had risen to demographic equivalence of India and China

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# A Heritage of Decentralization

- 15<sup>th</sup> century Western Christian Europe → quilt of numerous independent or autonomous units
  - Centralizing kingdoms of France, England
  - Hanseatic League
  - Teutonic Knights
  - Denmark, Sweden, Norway, Poland-Lithuania, Bohemia, Hungary
  - Principalities of Germany
  - Duchy of Burgundy
  - Switzerland
  - City-states of Italy
- Majority of units competed vigorously with each other

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# Military and Administrative Capacities

- 16<sup>th</sup> century → some kingdoms turned mercenary troops into standing armies
  - Stationed in star-shaped forts → 15<sup>th</sup> century Italian innovation
- Sweden introduced the line infantry in mid-17<sup>th</sup> century
  - Three-deep lines of musketeers
  - Led to regimental system
  - Permanent regiments; standardized, multi-color uniforms
- Replacement of matchlock musket by French-invented flintlock (1620-1630)
  - More rapid firing time
- 1660-1700 → French introduction of the bayonet
  - Pikemen phased out

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# Military and Administrative Capacities

- By 1750 → larger armies were more uniform in armaments, larger
  - Increased from a few thousand to tens of thousands of soldiers
- Military forces devoured tax money
  - Taxes expanded substantially between 1450 and 1550
- Taxes could not be raised without formal or informal assent of ruling classes, cities
- Taxation limits reached in mid-16<sup>th</sup> century
  - 200 years → raising money decreased central powers
  - Exception was the Netherlands
- 18<sup>th</sup> century → deterioration in state finances